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Planetary Quarantine Department

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PRIME CONTRACTOR TO THE U.S. ATOMIC ENERGY COMMISSION | ALBUQUERQUE, NEW MEXICO; LIVERMORE, CALIFORNIA; TONOPAH, NEVADA

Third Quarterly Report of Progress

for

Period Ending December 31, 1966

Planetary Quarantine Department

Sandia Laboratory, Albuquerque, New Mexico

December 1966

Project Nos. 340.229.00
340.229.01
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Work reported herein performed under NASA Contract Nos. R-09-019-040, H-13245A and W-12324.

TABLE OF CONTENTS

I - SYSTEMS STUDIES ACTIVITIES

(A) Model of Program Objectives

In the course of investigating the consequences of truncating the negative binomial distribution appearing in the work of Sagan and Coleman, it was found that their infinite model did not yield a conservative estimate for the probability, P_C, that a spacecraft be sterile. That is, the required probability in finite cases may be many orders of magnitude smaller than that required when assuming infinitely many missions may be sent to the planet in question. This raises some question as to the use of an infinite model.

On the other hand, the truncated model exhibits an extremely sensitive relationship between, P_C, and P_S, the probability of individual mission success. (See, "A Model for Planetary Quarantine Requirements", E.J.Sherry, C. A. Trauth, Jr., Sandia Laboratory Research Report, SC-RR-66-588). This sensitivity is so severe that it is intuitively unreasonable.

Work is now underway to develop a model which accounts for both primary objectives, experimental success and non-contamination, while at the same time lacking the aforementioned sensitivity. Several possible approaches are now being investigated.

(B) Sterilization Models

The basic assumption of the modeling done so far is that the microbial death rate at a given time t is proportional to the population times a factor accounting for the damage suffered by the population after exposure to the lethal heat environment.

The model resulting from this approach is given by

$$y'(t) = y(t) \int_0^t K(s,t)y(s)ds \tag{1}$$

where $y(t)$ is the expected population at time t, $y'(t)$ the death rate of this population, and $K(s,t)$ the damage kernel.

In comparison, the usual exponential model yields

$$y'(t) = ky(t)$$

implying a constant damage factor.

In order to avoid a data fitting approach, certain physical assumptions were made regarding the probable causes of death, these causes were related to the damage kernel $K(s,t)$, and a solution, $y(t)$, obtained in this way was then compared with existing data.

First, it was assumed that death results from a chemical reaction of the form $A \xrightarrow{c} B$, c being the reaction rate, and then for a first order reaction

$$K(s,t) = d[1-e^{-cs}]$$

where d is a parameter, and for a second order reaction,

$$K(s,t) = \frac{dcs}{1+cs} .$$

Using some of Silverman's data at $120^{\circ}C$ (Figs.1,2) and $106^{\circ}C$(Figs.3,4), the parameters c and d were calculated for both orders of reactions. In both cases, the Arrhenius equation (which is, itself, a chemical reaction equation) was used in combination with equation (1) to predict the results at $135^{\circ}C$. A comparison of these predictions with Silverman's data at $135^{\circ}C$ is shown in Figures 1 and 2 (denoted "Predicted").

Research is continuing in this area with the assumption of somewhat more complex chemical reactions. Under such assumptions it now appears that solutions to equation (1) have nonlinear characteristics not unlike some of the data obtained by Angelotti.

A preliminary report is being prepared.

(C) Program Analysis and Planning

A document is being prepared which describes a theory of program analysis and planning being used within this organization. Basically, the theory consists of a heirarchy of objectives interrelated with quantitative models whenever possible. This approach, while somewhat complicated, promises a more complete view of a program than does the approach which isolates a problem and analyzes it intensely without discovering how the problem may affect, or be affected by, other factors in the program.

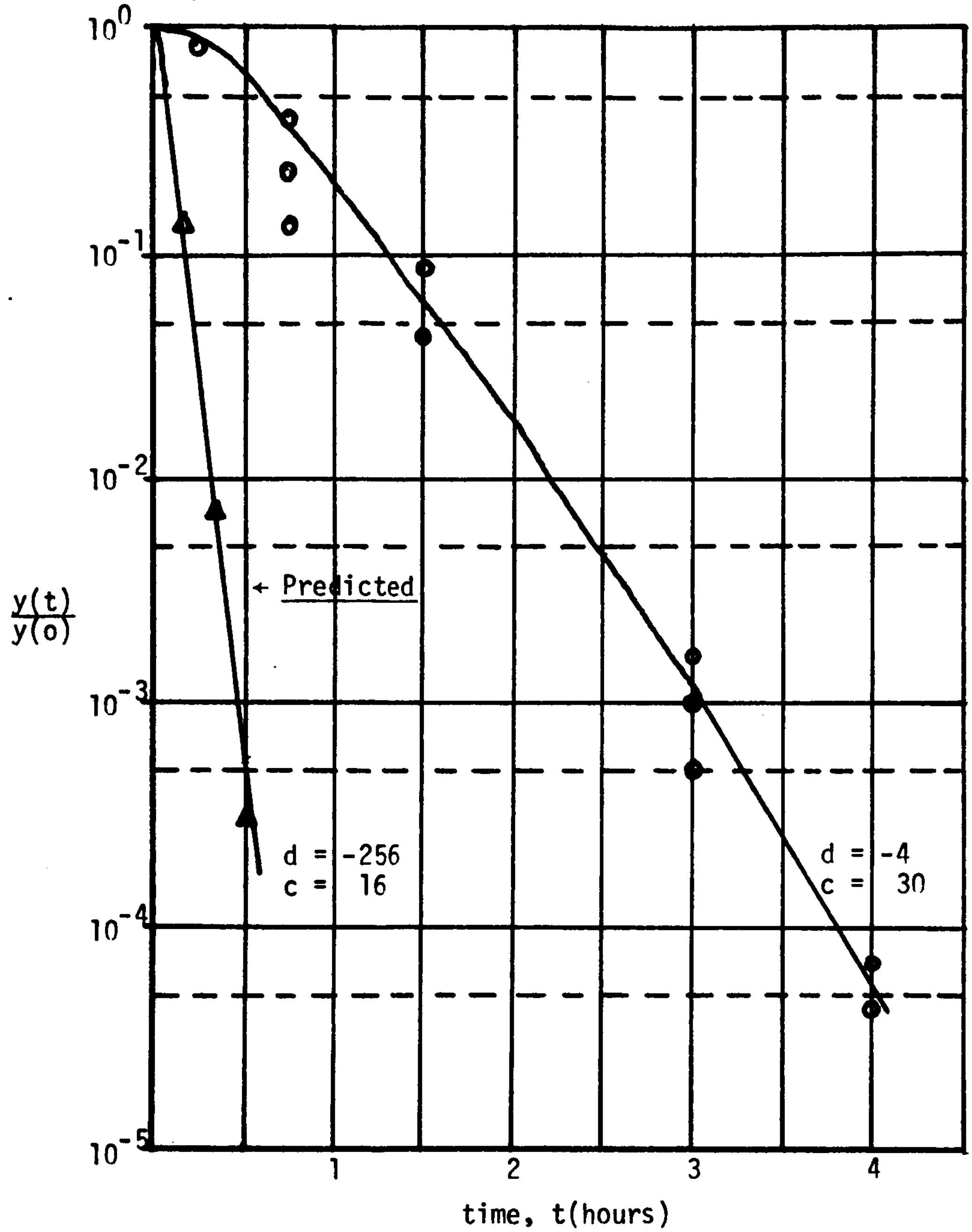

Figure 1 - First Order Reactions

Δ - Data at 135°C, Silverman

o - Data at 120°C, Silverman

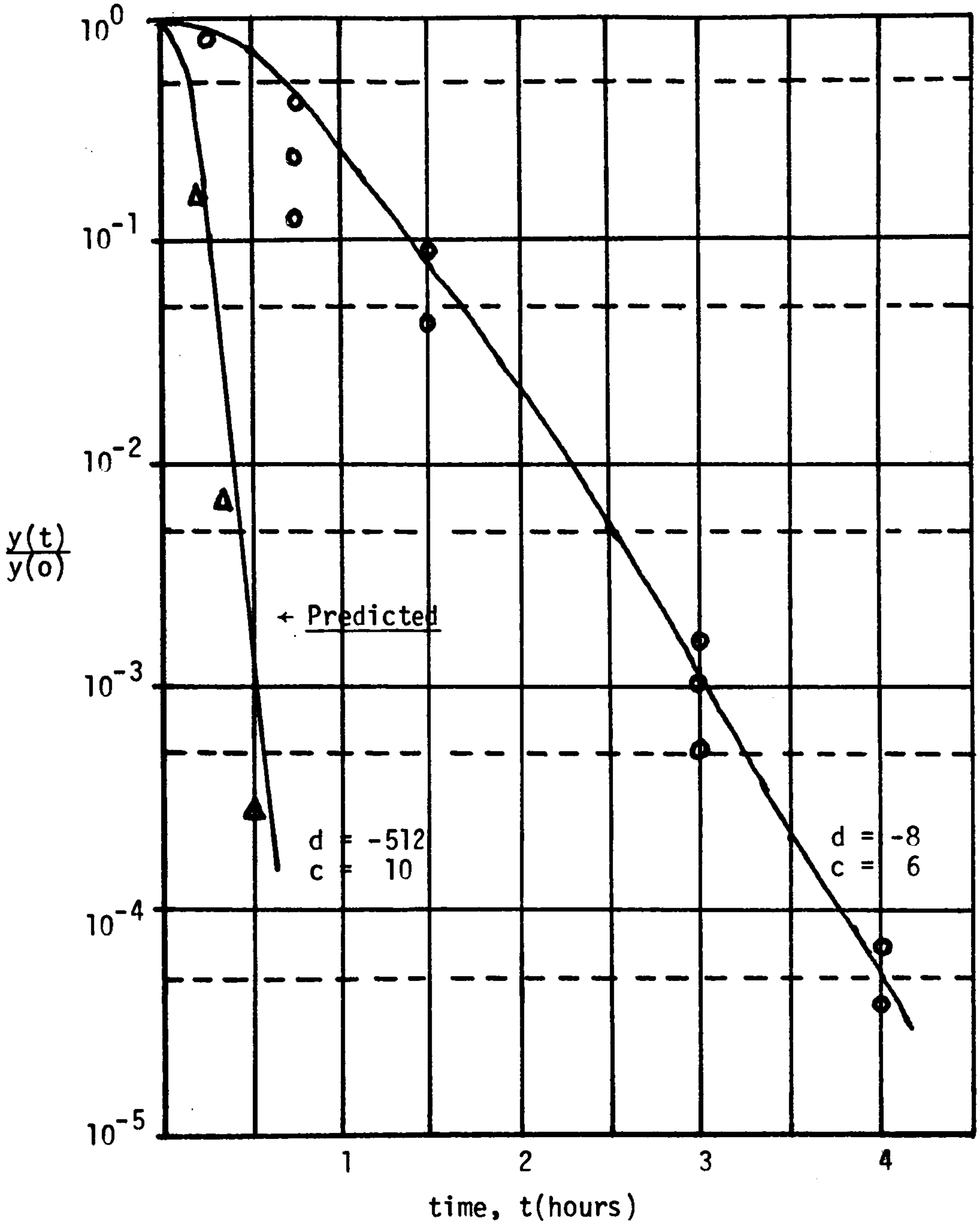

Figure 2 - Second Order Reactions

Δ - Data at 135°C, Silverman

o - Data at 120°C, Silverman

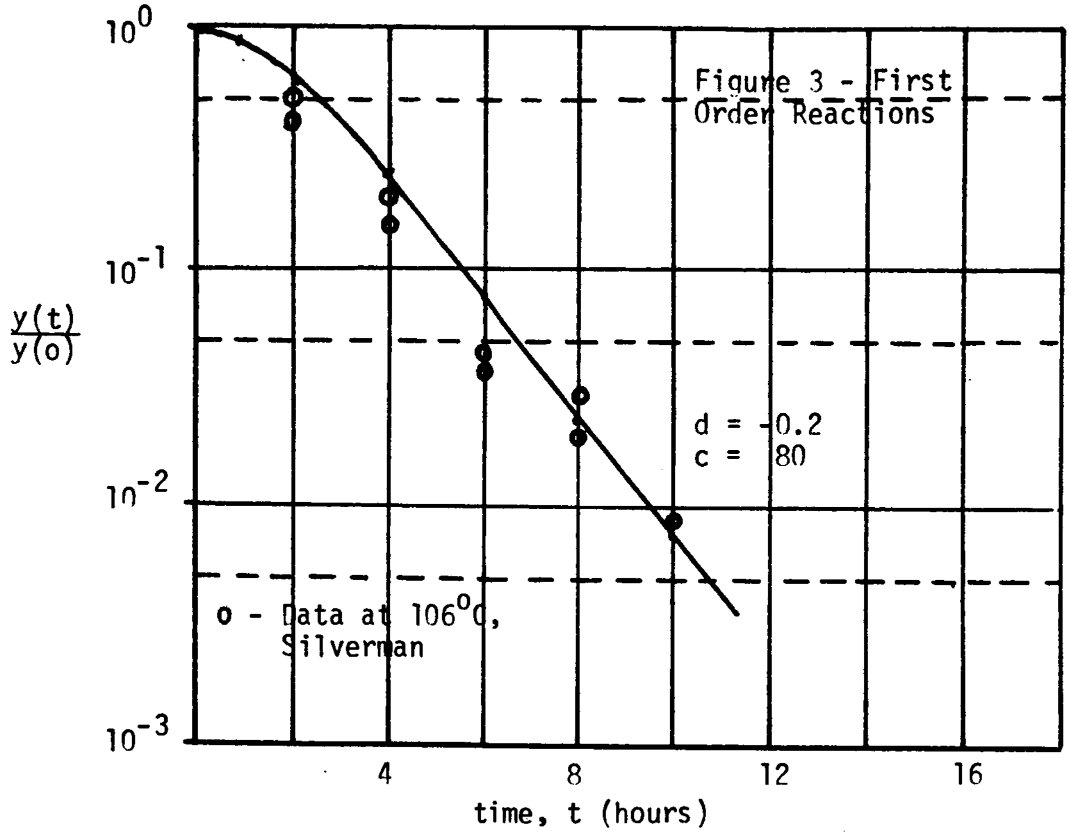

Figure 3 - First Order Reactions
10^0
10^{-1}
10^{-2}
10^{-3}
$\frac{y(t)}{y(o)}$
d = 0.2
c = 80
o - Data at 106°C, Silverman
4
8
12
16
time, t (hours)

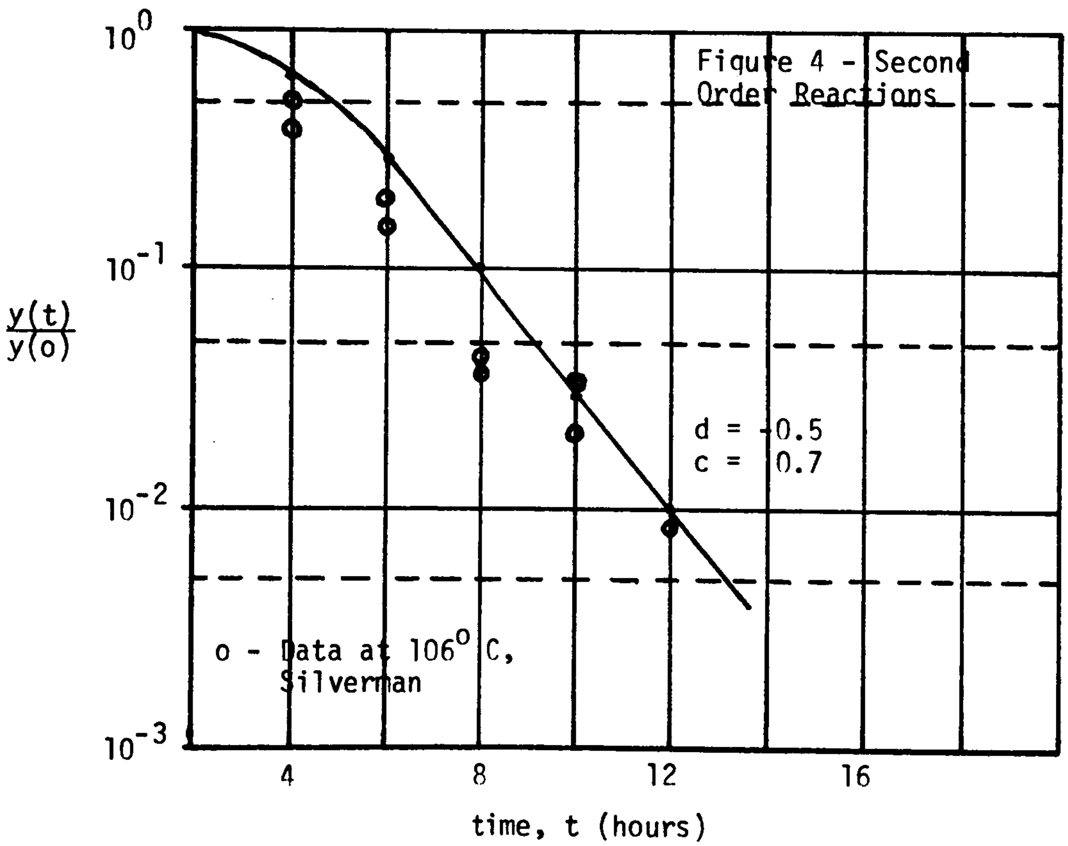

Figure 4 - Second Order Reactions
10^0
10^{-1}
10^{-2}
10^{-3}
$\frac{y(t)}{y(o)}$
d = 0.5
c = 0.7
o - Data at 106° C, Silverman
4
8
12
16
time, t (hours)

II - SYSTEMS SUPPORT ACTIVITIES

(A) Vacuum Probe Development

During the last quarter work has continued on the development and testing of a vacuum probe to be used as an implement for the bacterial assay of "worst case" models and, perhaps, space hardware. The latest versions of the probes have been constructed of teflon in order that they may be used on delicate or polished surfaces without the danger of scratching the surface. With the advent of the teflon probe tip, the percentage of microorganisms which can be removed from a smooth, dry surface has been improved considerably. This removal percentage is consistently better than 90% when loading all types of smooth, dry surfaces with dry Bacillus subtilis var. niger spores, both water and ethel alcohol suspensions of Bacillus subtilis var. niger spores, skin flakes, or soil spores.

The vacuum probe seems to have other very desirable characteristics other than its ability to remove bacteria from surfaces. One of these characteristics is that of breaking up clumps of organisms into single cells (or at least smaller clumps) by a high velocity air jet. This enables one to get a much better estimate of the total number of bacteria on a surface.

The majority of the work being done on the probe system at this time involves determining the best sampling device to be used with the probe. One model receiving major attention uses an incorporation of the teflon probe and a membrane filter housing and filter. This model is very mobile and can be used in sampling many configurations of surfaces for bacterial spores. It is also very convenient since the entire assembly can be very easily sterilized and since no agar or containers containing agar are needed in the vicinity of the surface which is to be sampled. Other sampling devices are also being tested in conjunction with the probe to determine their areas of merit. A preliminary report of the probe development is now being prepared and will be published in early February 1967.

(B) Fine Particle Physics Studies

A study is underway to determine the nature of bacterial deposition on different surface configurations while in a laminar air flow clean room. The outcome of this study will be combined with other information to determine a "worst-case" model for bacterial collection within a laminar-flow clean room environment.

Studies to determine the microbial profile of a laminar downflow surgical theater have been continued. Air sampling results indicate a low level of airborne viable particle contamination (0.00 to 0.2 per cubic foot of air) at the wound site. Airborne microbial contamination levels beneath the operating table and on the floor at the head of the table were somewhat higher (0.1 to 6.0 viable particles per cubic foot of air). Presently, the isolated organisms are being identified by a combinatorial analysis system. The sampling studies will be continued in the laminar down flow surgical theater and also will be expanded to include a conventional room in the same surgical suite.

(C) Contamination Control Study (NASA Contract H-13245A)

The contract provides for collecting and evaluating available information on contamination control, performing necessary research to assure accuracy and completeness of information and data; and organizing the information into a document for use by Design and Manufacturing Engineers.

The objectives of the studies are to obtain sufficient background information and data to formulate guidelines to aid engineers in:

1. designing product with a minimum realistic need for contamination control,
2. designing product to facilitate decontamination (cleaning, etc.)
3. determining more realistic and economic cleanliness level requirements for product (as opposed to "make it as clean as possible"),
4. designing product such that it generates a minimum amount of contamination control, and
6. developing effective cleaning and other decontamination processes in shorter time, etc.

Progress During the Quarter Include:

1. Development of a model (in outline form) for the general field of contamination control to relate sources of contamination, methods of detecting contamination, and methods of contamination removal to specific contaminant types and the contaminated environments (air, parts, surfaces, etc.).
2. The preparation of a preliminary, general outline of information to be studied.
3. A request for a retrospective and continuous search of literature (journals and reports) from the University of New Mexico Technology Applications Center. The request was made through the Sandia Corporation Library and was based upon key words taken from the preliminary outline mentioned above and from the model for contamination control.
4. Obtaining literature (including some books from the library) relative to monitoring and cleaning.
5. Continuation of cataloguing and studying information on hand. The study has revealed that some general information in processing books

is slanted away from rather than toward processing for contamination control.

6. Organization of ideas relative to experiments in product cleaning generation of contamination, and materials properties relative to contamination control. These ideas will be firmed up as the literature study becomes more nearly complete in the respective areas of concern.
7. The preparation and presentation of a quarterly report on the project to NASA personnel at Huntsville on December 13, 1966.
8. Preparation of a list of possible titles to be considered for the document. Our plans are to discuss these, with our recommendation, at a future meeting with the NASA Contamination Control Panel.
9. Preparation of tentative plans for a joint NASA/AEC sponsored symposium on current and advanced concepts in instrumentation and automation in contamination control.

(D) Principles of Contamination Control Document (NASA Contract W-12324)

A preliminary rough draft was completed in early December of the "Principles of Contamination Control" document. It was submitted at that time to the Office of Technical Utilization and to the NASA Contamination Control Committee. A review of the document was presented to NASA at a regular quarterly progress review meeting held at Huntsville, Alabama, December 13, 1966.

Comments on the document will be presented January 24 at a joint meeting with the committee at Sandia. After such comments have been reviewed, a final draft will be prepared for submittal to NASA on or before March 1, 1967.

III - MISCELLANEOUS

(A) Publications

1. Sherry, E. J., and Trauth, C. A., "A Model for Planetary Quarantine Requirements," SC-RR-66-588, September 1966.
2. V. L. Dugan, "Production of Low Concentration Particulate Aerosols by a Sonic Disseminator Technique," SC-RR-67-14, December 1966.

(B) NASA Short Course

The NASA short course "Basic Environmental Microbiology for Engineers" at Phoenix, Arizona, was attended by V. L. Dugan and A. L. Wyer on December 5-9, 1966.

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